ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (2) (8)

Author: Mr. Albert Caubet
University of Strathclyde, United Kingdom

Dr. James Biggs
University of Strathclyde, United Kingdom

AN INVERSE DYNAMICS APPROACH TO THE GUIDANCE OF SPACECRAFT IN CLOSE PROXIMITY OF TUMBLING DEBRIS

Abstract

Active Debris Removal (ADR) operations involving contact with an uncooperative target present challenges for GNC design. Real-time path planning, robust control, obstacle avoidance and accurate navigation are required to perform an efficient autonomous docking manoeuvre. This paper presents a 6 degrees-of-freedom (DOF) motion planning technique, for position and attitude guidance, based on polynomial shaping of the trajectories. Each 6 DOF waypoint is connected smoothly to generate complex trajectories that can be used for obstacle avoidance. With the inverse dynamics method, the forces and torques are computed using an internal model, thus it is possible to ensure that the actuators operate within the constraints. In addition, it is demonstrated that this class of motion can be optimised to minimize time or fuel consumption. The trajectories generated are tracked using a simple feedback controller which corrects model inaccuracies, environment disturbances and navigation errors, where the estimated forces and torques are used as feed-forward inputs. An adaptive control is also considered to account for large variations in mass due to fuel consumption that may occur in an agile chaser spacecraft. The scenario considered in this paper involves two spacecraft, (i) a larger carrier that observes the target from a safe distance providing navigation data using a vision-based system, and (ii) a smaller autonomous module that performs a docking maneuver. The example used here is based on the ASEM (Attitude Stabilization Electromagnetic Module) whose purpose is to detumble the debris when attached to it. Results show that the 6 DOF motion planning method is computationally efficient and can quickly generate feasible trajectories, subject to the constraints involved, for docking safely with an uncooperative target.